2651

MOISTURE DETERMINATION IN HONEY WITH AN EICHHORN-TYPE HYDROMETER

JONATHAN W. WHITE, JR.

Eastern Utilization Research and Development Division
Agricultural Research Service
United States Department of Agriculture,
Philadelphia, Pennsylvania 19118, *U.S.A.*

SUMMARY

An Eichhorn-type hydrometer has been constructed and subjected to a preliminary evaluation for the determination of moisture in honey. This instrument, in contrast to the conventional type, encloses a fixed volume of honey and is suspended in water. The data obtained indicate that it can be used to determine the moisture content of honey with at least the accuracy of the hand refractometer.

INTRODUCTION

Because of its influence on fermentation, 'body', granulation, and hence on quality, the moisture in honey is a very important constituent. For control of these factors it is essential that moisture content be known with a fair degree of accuracy.

Methods for determining the moisture content of honey have been studied for many years (for a review see White, *in press*). The standard laboratory method (Horwitz, 1960) uses vacuum drying under carefully specified conditions. Because of the slow and cumbersome nature of this determination, indirect instrumental methods have been developed, such as: measurement of refractive index (Auerbach & Borries, 1924; Chataway, 1932); specific gravity by weighing (Fiehe & Stiegmuller, 1912; Auerbach & Borries, 1924; Snyder, 1933); hydrometry (Chataway, 1932, 1933; Marvin, 1933; Wedmore, 1955; White, *in press*). Viscosity measurement has also been suggested (Chataway, 1932; Oppen & Schuette, 1939).

Of all these methods, the refractive index using laboratory-type instruments shows the best correlation with the standard drying procedure, and is the simplest and most rapid method. The instrument required is rather expensive and in the honey industry is usually used only by larger packers. A number of small abridged 'hand' versions are commercially available at low enough prices to be attractive to most packers and some beekeepers. These instruments are usually calibrated in 0·2% moisture increments, which might be thought sufficient for practical purposes. In an examination of this type of instrument, Pearce and Jegard (1949) found a standard error of ± 0·4%. In practice it is rather unusual to find two of these instruments in agreement. Even so, a temperature-compensated hand refractometer, occasionally recalibrated, is generally satisfactory for routine moisture determination of honey for many purposes.

A simple and widely used method for determining the solid content of solutions (brines, vinegars, sugars, acids, etc.) is the measurement of specific gravity with a floating calibrated spindle. Efforts have been made to apply this to determination of honey moisture. Chataway (1932) examined the performance of two instruments then in commercial use on honey. Moisture values obtained by a small one varied over 2% on a single sample; a larger one was more accurate, with readings varying about 0·8%. She later (1933) designed a special hydrometer for honey and found agreement with values from refractive index within about ± 0·12% moisture. Her instrument was a Baumé hydrometer 32 cm long with a stem diameter of about 5 mm; 1 mm length of the stem corresponded to 0·13% water in honey. She specified use of warm honey (120°F, 49°C) and the layering of 5 ml water on the surface to allow attainment of equilibrium in the viscous material, with reading in 10 – 15 minutes. An average difference between moisture content by this procedure and by refractive index was 0·15% for 38 samples.

The most common type of hydrometer consists of an elongated bulb, usually glass, with a long stem. The dimensions and weight of the bulb are adjusted so that the hydrometer floats upright in the test liquid with part of the stem emerging. The amount emerging is a function of the density of the liquid. The stem can be calibrated to read in specific gravity or in composition of the liquid. A thermometer may be incorporated to permit temperature correction.

The Eichhorn-type hydrometer has features that might be useful for moisture determination in honey. In this instrument (Eichhorn, 1890) a fixed volume of test material is placed inside the hydrometer which is then floated in water, with the amount of emerging stem indicating composition as with the conventional type. The amount of stem emerging depends upon the weight of the hydrometer itself plus the weight of the fixed volume of sample, which varies with its density.

The obvious advantage of this type of instrument, floating in water, over the more common type floating in honey is that the equilibrium position in water is reached far more rapidly and scale reading is easier.

The instrument patented by Eichhorn (1890) was intended for measuring specific gravity of gases, corrosive liquids or other liquids in quantities too small for the flotation of a conventional spindle. Examples of the many later patents using the principle are those of Kessler (1920) who provided easier filling, Hartley (1935) to improve means of closure, Huberti and Lawrence (1936) to increase accuracy, and Segal (1950) to determine fat content of chopped meats.

The applicability of this type of instrument to accurate determination of the moisture content of honey has been examined at this laboratory. The last of several models has been given limited testing; it appears that this approach is sound. If this conclusion is supported by further testing with additional fresh, natural honey samples, preferably of moisture content over a range of 12 – 25% as determined by drying, it is conceivable that a relatively cheap plastic model could be manufactured to provide accurate moisture determination in honey at low cost. Since honey research has been discontinued at this laboratory no additional work will be carried out here; the data are provided to encourage further testing and development of the instrument.

EXPERIMENTAL

Several models with differing configurations were constructed of aluminium alloy (dural) to test various means of fixing a definite, reproducible volume of moisture in honey over a range of about 15% moisture. The limits of the range (10 – 25, 12 – 27, etc.) are adjustable by adjusting the amount of lead shot.

Nine honey samples were used to obtain the calibration curve in Fig. 2. Two additional points (the two of highest moisture content) were obtained by diluting two of the honeys. Moisture was determined by using a laboratory-type Abbé refractometer with the Chataway conversion (Horwitz, 1960).

With the dimensions selected for the model, 1·0 mm of stem length was equivalent to 0·10% moisture in the honey (Fig. 2). The sensitivity is of course a

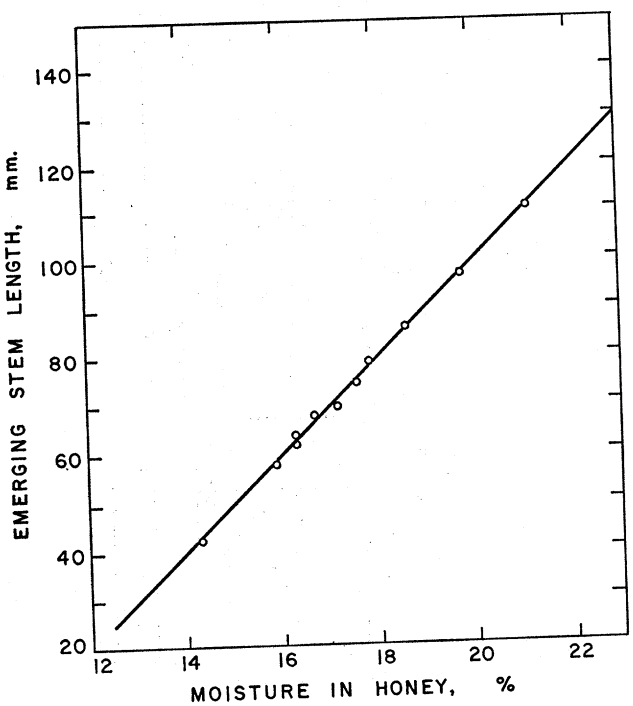

FIG. 2. Effect of moisture content of honey (determined refractometrically) on length of hydrometer stem emerging from water bath. Temperature of sample and water bath 27°C

function of the cross-sectional area of the stem. This stem was 0·2495 inches in diameter [6·34 mm], with a cross-sectional area of 31·53 mm². If a stem diameter of 0·1875 inches (3/16) had been selected, with 17·81 mm² area, 0·10% difference in moisture content would cause 1·79-mm difference in depth. Use of a stem of rectangular cross-section would permit easier scale marking and reading.

Effect of temperature

For a preliminary examination of the effect of temperature on the measurement, a honey in the hydrometer at 27°C (the calibration temperature) was suspended in water at several temperatures and the emerging stem length measured immediately, before significant temperature change. Results, in Table 1, show that each degree Centigrade difference in temperature between the honey and the honey in the instrument. Fig. 1 shows the structure of the instrument in its present state of development. It consists of two integral chambers: the upper float, into which lead shot can be placed to adjust the range, and the lower sample-compartment, with means to fix accurately the volume contained therein and to hold the two parts firmly together.

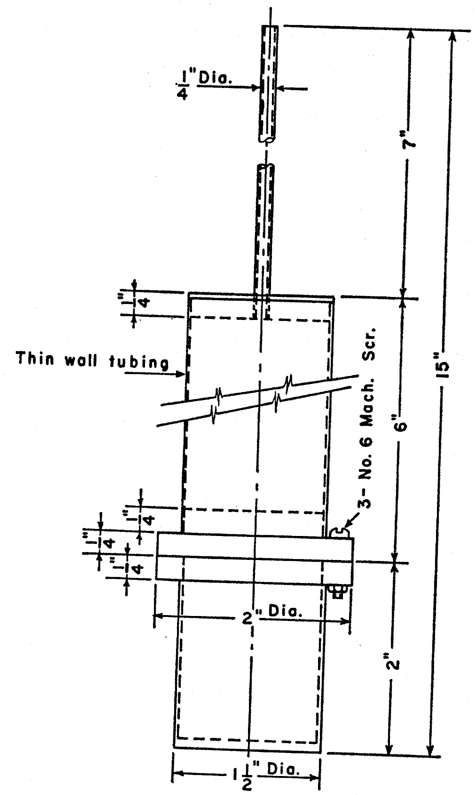

FIG. 1. Eichhorn-type hydrometer for determining moisture in honey

The volume of honey held by the instrument is fixed by overfilling the cup and sliding the lid (with the float) horizontally across the surface, one screw serving as a pivot. This cuts off and rejects excess honey. The two parts are firmly fixed by the three screws.

In a test of reproducibility of filling, the instrument was filled, weighed, emptied, cleaned, refilled, and reweighed. The two weights agreed to 0·01 g. To test overall reproducibility, the instrument was filled, floated, and the stem reading noted; then the hydrometer was emptied, cleaned and dried. This process was repeated four times. Length of stem emerging for the five determinations was 92, 92, 92, 92, 91·5 mm.

The stem of the instrument is hollow to allow adjustment of depth while floating. This was a convenience in the experimental models but not essential to operation. With the dimensions given, the stem is sufficiently long to measure

EICHORN, A. (1890) Hydrometer. *U.S. Pat.* 422 962

FIEHE, J. & STEGMÜLLER, P. (1912) Nachprüfung einiger wichtiger Verfahren zur Untersuchung des Honigs. *Arb. K. GesundhAmt.* 40 : 305–356

HARTLEY, J. A. (1935) Hydrometer. *U.S. Pat.* 2 006 549

HORWITZ, W. (ed.) (1960) Official methods of analyses of the Association of Official Agricultural Chemists. *Washington : Assoc. Offi. agric. Chem.* 9th ed.

HUBERTI, J. A. & LAWRENCE, H. J. (1936) Hydrometer. *U.S. Pat.* 2 037 238

KESSLER, J. H. (1920) Specific gravity tester. *U.S. Pat.* 1 360 537

MARVIN, G. E. (1933) Methods for determining the weight per gallon of honey. *Am. Bee J.* 73 : 426–428

OPPEN, F. C. & SCHUETTE, H. A. (1939) Viscometric determination of moisture in honey. *Ind. Engng. Chem. analyt. Edn.* 11 : 130–133

PEARCE, J. A. & JEGARD, S. (1949) Measuring the solids content of honey and of strawberry jam with a hand refractometer. *Can. J. Res.* F 27 : 99–103

SEGAL, D. L. (1950) Lipometer. *U.S. Pat.* 2 506 973

SNYDER, C. F. (1933) Report on drying, densimetric, and refractometric methods. *J. Assoc. offi. agric. Chem.* 16 : 173–175

WEDMORE, E. B. (1955) The accurate determination of the water content of honeys. Part I. Introduction and results. *Bee Wld* 36 : 197–206

WHITE, J. W., JR. (*in press*) Physical characteristics of honey. Chapter from *Honey*. ed. E. Crane *London : Heinemann*

water in which the hydrometer is suspended introduced a difference of 1·75 mm in the position of the hydrometer, corresponding to 0·17% moisture. If the bath temperature is higher, the honey will appear more dense (lower in moisture).

TABLE 1. Effect of bath temperature on flotation of hydrometer

Bath temperature (°C)	*Emerging stem length* (mm)
19	108
27	97
41	69

Honey at 27° in hydrometer; emerging stem length measured before significant temperature change.

A calibration line, such as that in Fig. 1, is correct only when both sample and water are at the calibration temperature. If both honey and water are at the same higher temperature, a parallel calibration line below the one shown would be obtained. The final position of the stem would be about 1·4 mm lower for each degree Centrigrade that the temperature (of honey and water) is higher. This value is an approximation and should be verified.

If the sample and the bath differ in temperature, and neither is at the calibration temperature, two corrections would be required. This should be avoided by having both sample and water at the same temperature (preferably the calibration temperature, otherwise a correction must be applied).

Other sources of error

After filling and closing the instrument, any excess honey must be washed from the surface with room-temperature water. Failure to fill the sample cup completely will produce moisture readings that are too high. When the hydrometer is taken apart after use, the full cup should be examined to verify absence of significant air bubbles. It was calculated that an air bubble of 3·7 mm (about ⅛ inch) diameter in the sample will make the stem emerge 1 mm more, equivalent to 0·10% water. A few bubbles of ½-mm diameter in the sample can be ignored.

When the hydrometer is placed in water, care must be taken to detach any air bubbles clinging to the exterior.

ACKNOWLEDGEMENT

The possibility of using an Eichhorn-type hydrometer for this purpose was suggested to me by the late George P. Walton before his retirement from honey research in 1949.

The contribution of Robert R. Calhoun, Jr., in design and fabrication of the various models of the hydrometer is gratefully acknowledged.

REFERENCES

AUERBACH, F. & BORRIES, G. (1924) Die Bestimmung der Trockenmasse echter Honige. *Z. Unters. Nahr.- u. Genussmittel* 48 : 272–277

CHATAWAY, H. D. (1932) Determination of moisture in honey. *Can. J. Res.* 6 : 532–547

CHATAWAY, H. D. (1933) The determination of moisture in honey by the hydrometer method. *Can. J. Res.* 8 : 435–439

BEE RESEARCH ASSOCIATION

The Bee Research Association is the central clearing house for information about research on bees and related subjects, including beekeeping and covering all species of bees.

The Association publishes three journals:

Journal of Apicultural Research, an international journal printed in English, for original research papers.

Apicultural Abstracts, a quarterly survey of scientific papers from world literature, in English.

Bee World, the official organ of the Association, which provides beekeeper and scientist with news and articles on recent developments.

Members are entitled to receive one or more of these journals. Membership has other advantages, including use of the Association's extensive Library of books, journals, reprints, translations and pictures, which are lent by post to any country in the world.

The journals can also be obtained by subscription.

Further details, including a complete list of B.R.A. publications, from: